Space Weather Technical Forecast

Issued on Saturday, 07 January 2023 at 13:03 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of X-class flares throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with an M1 flare at 07/0052 UTC, originating from AR3182 (Fki/Beta-Gamma), which remains the largest region on the visible disc. This region has a complex magnetic structure, which may contain a delta spot, although the region needs to rotate further across the Sun to be able to obtain a better analysis. There are four other sunspots regions on the visible disc, of which, AR3181 and AR3183 have Beta-Gamma configurations, although are smaller than AR3182. These regions have the potential to produce significant flares. AR3180, despite being a large region, appears to be stable and is now considered a Beta configuration. AR3177 has continued to show some decay and is now classified as a Cro/Alpha, which has a history of producing large C-class flares. The weak and unnumbered sunspot which emerged in the northwest quadrant has continued to decay and fade back to plage. No Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1, reached elevated levels, with a peak of around 520km/s at 06/1730 UTC, before a gradual decline down to slightly elevated levels, currently near 430km/s. Density was average to above average, peaking at 13 ppcc.
Total magnetic field strength (IMF) started the period at Moderate levels, peaking at 11nT, before declining to the current weak levels. The north-south component Bz was predominantly positive, with isolated weakly negative fluctuations, reaching -6 nT at 06/1235 UTC. Phi angle was negative (towards the Sun) throughout. Geomagnetic activity remained at Quiet levels (Kp 0-1). The solar wind environment indicated a connection to a HSS from either CH60 or CH61.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) has been at background to moderate levels, peaking at 115 pfu at 06/1915 UTC. The 24-hour integrated electron fluence remained below the Active threshold with a falling trend, reaching 1.74e6 integrated pfu by 07/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Low to Moderate, with a chance of X-class flares through the forecast period, these most likely from AR3182.

Solar Wind / Geomagnetic Activity: The current high speed stream (HSS), from either coronal hole 60 or 61, is likely to persist today and tomorrow (7th and 8th), before possibly declining through day 3 (9th). During day 4 (10th) a new HSS from CH62/- is expected to arrive, with speeds again around 450-500 km/s. Therefore for much of the period the solar wind is expected to be at slightly elevated to elevated levels, although probably temporarily decreasing to background levels on day 3 (9th). Geomagnetic activity is expected to be mostly Quiet (Kp 0-2) but with isolated Unsettled (Kp 3) intervals possible today and tomorrow. Day 4 conditions are likely to increase slightly to become Unsettled, perhaps Active (Kp 4).

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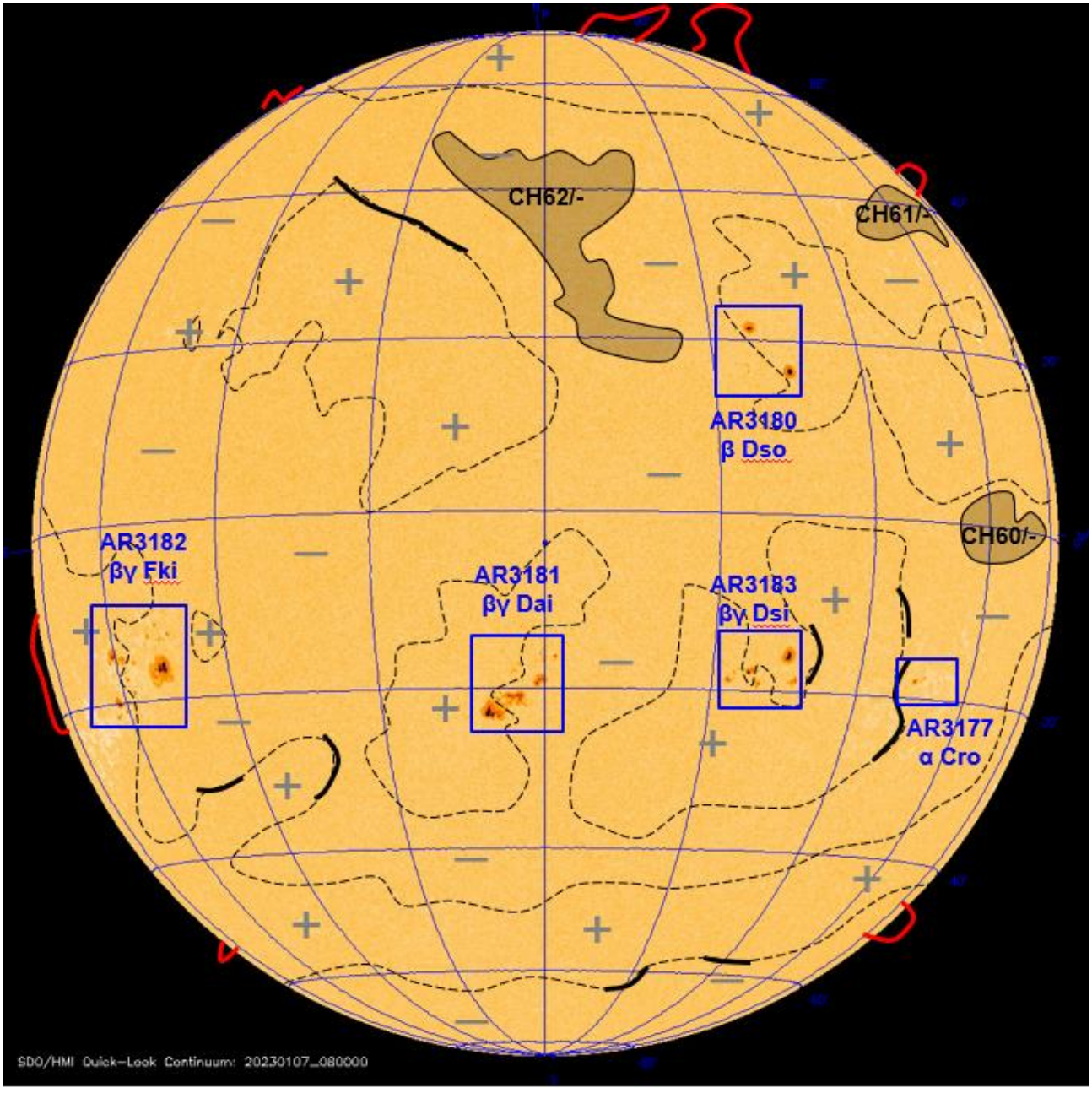
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout with a chance of rising alongside any notable flares, giving a slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) levels are expected to be at background to moderate levels. Therefore the corresponding electron fluence values are forecast to remain below the Active (1e8 integrated pfu) levels, despite an increasing trend.

Figure 1. Solar Analysis Valid 07/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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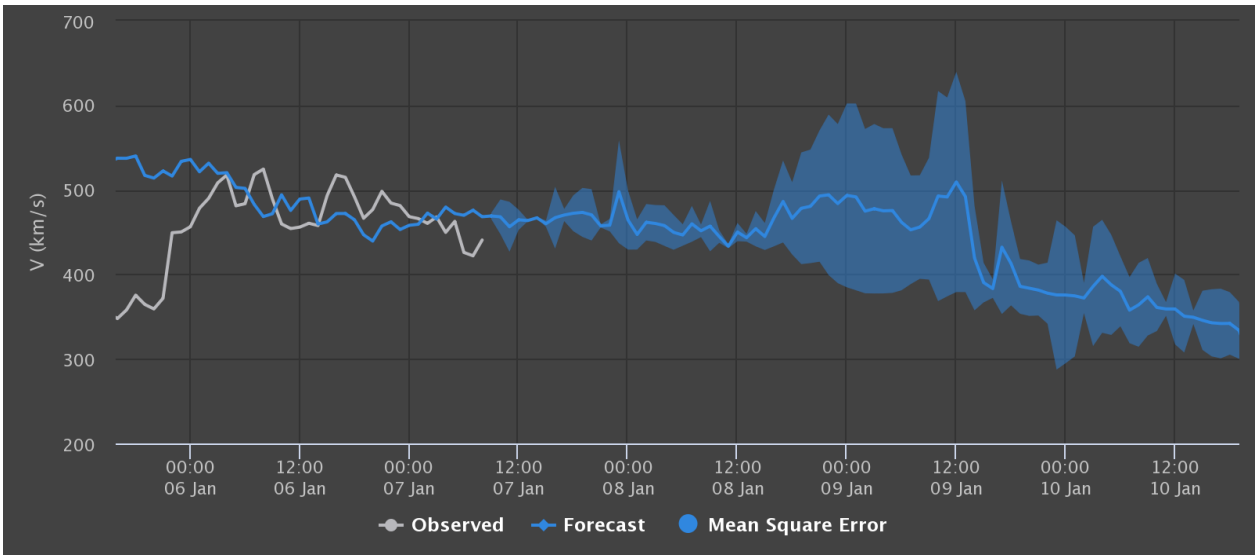
Geomagnetic Storms:

Current solar winds are slightly elevated indicative of the connection to a HSS, from either CH60 or CH61. Looking at Stereo Ahead data, where the solar wind speeds appear to still be around 500 km/s, which would indicate that the HSS will be slow to decline, persisting around current levels for at least another 24 hours or so. Persistence would also support a gradual decline in the HSS. The solar wind may decline to reach background levels temporarily through day 3 (9th), before a further HSS from CH62 is likely to arrive through day 4 (10th) with solar winds likely to return to 450-500 km/s.Geomagnetic activity is expected to be mostly Quiet (Kp 0-2) but with isolated Unsettled (Kp 3) intervals possible today and tomorrow. Day 4 (10th) conditions are likely to increase slightly to become Unsettled, perhaps Active (Kp 4).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC Persistence model – shows solar winds remaining mostly slightly elevated before the arrival of HSS from CH60 by day 4 (10th)



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Radio Blackouts - X-Ray Flares:
There are currently five numbered sunspot regions on the visible. AR3182 remains the largest and most magnetically complex in the southeast quadrant, and is classified as a Fki/Beta-Gamma. This region continues to show some growth in its intermediate spots. Currently no delta spots are thought to be present, but there is potential for delta spots to form if trailing spots continue to show some consolidation. AR3177 in the western hemisphere remains a uni-polar region, and continues to slowly decay. Some minor growth was observed in AR3181 and AR3182. Some consolidation in the intermediate spots of AR3183, with the potential for a delta spot to develop in the region.

Solar activity has been Moderate over the past 24 hours, with an M1 flare observed at 07/0052 UTC, originating from AR3182 (Fki/Beta-Gamma), which remains the largest region on the visible disc. Solar activity is likely to be mainly Low to Moderate with a chance of X-class flares. AR3182 remains the most likely region to produce a significant flare, but most remaining areas have contributed C-class flares over the past 24 hours and therefore cannot be dismissed.

There is the potential for further regions to rotate around from the east limb, or at least, an extension of AR3182, which shows plage trailing behind. Recent EUVI imagery does show some bright flux region just around the east limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	20	20	20	20

Figure 3: GOES-16 X-Ray flares – shows the recent M1 flare from AR3182 (see SDO/AIA 93 image below)

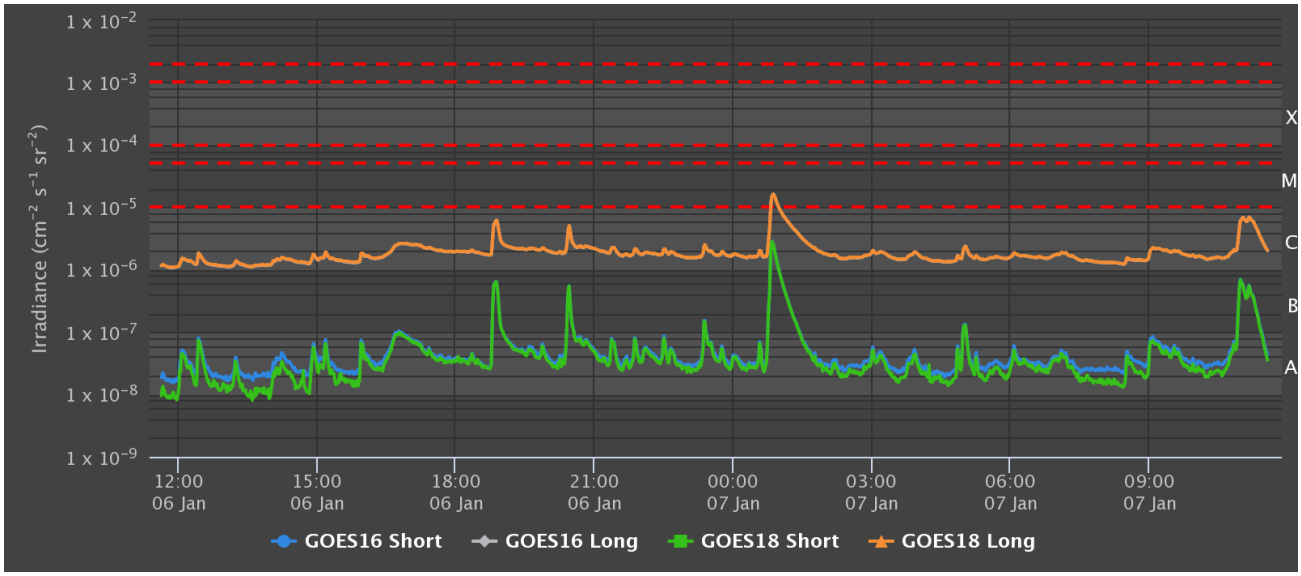

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Figure 4 – SDO/AIA 94 – shows location (red box) of the M1 flare, which originated from AR3182.

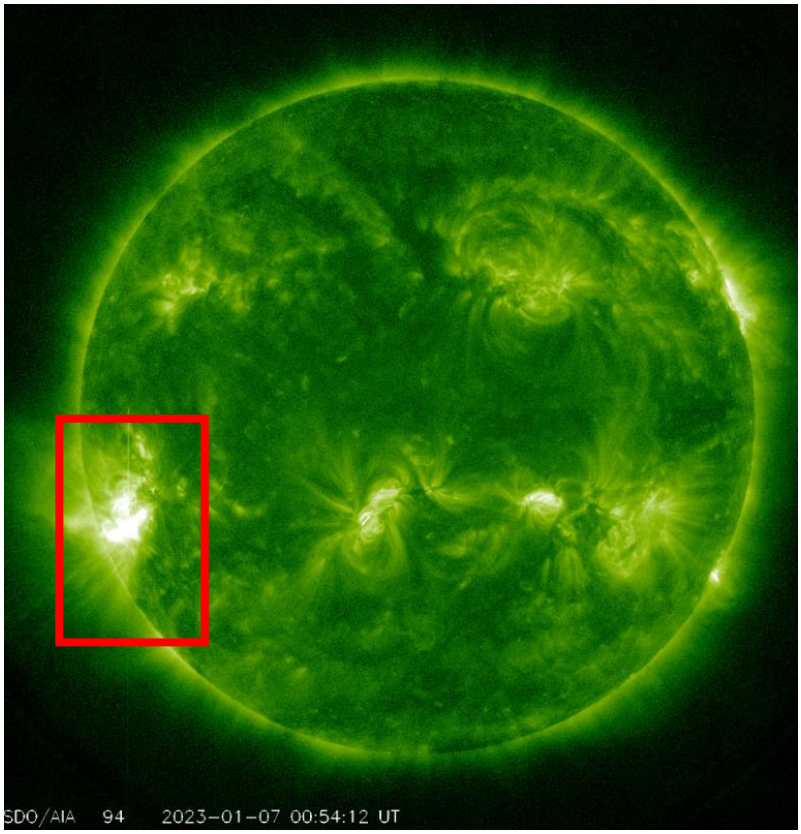

Figure 5 – Recent SDO/HMI intensitygram (left) and megnetogram (right) showing AR3182.

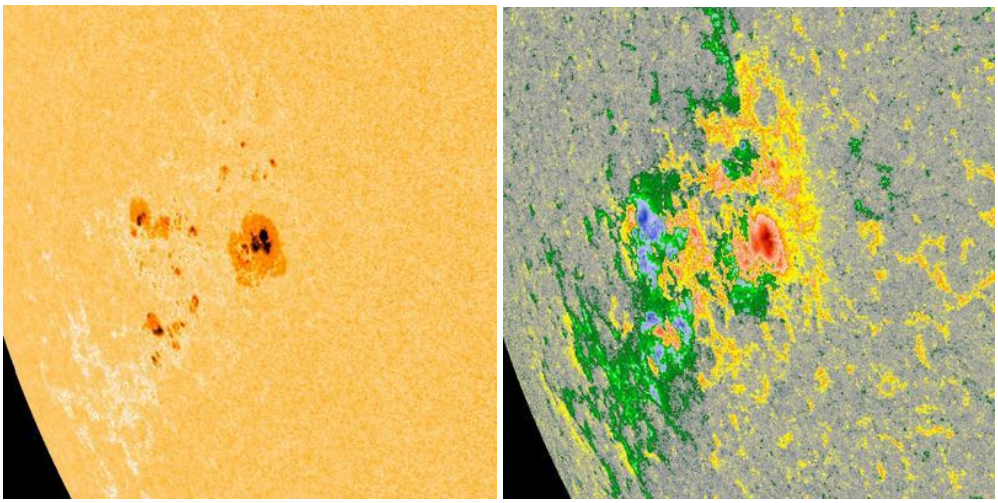

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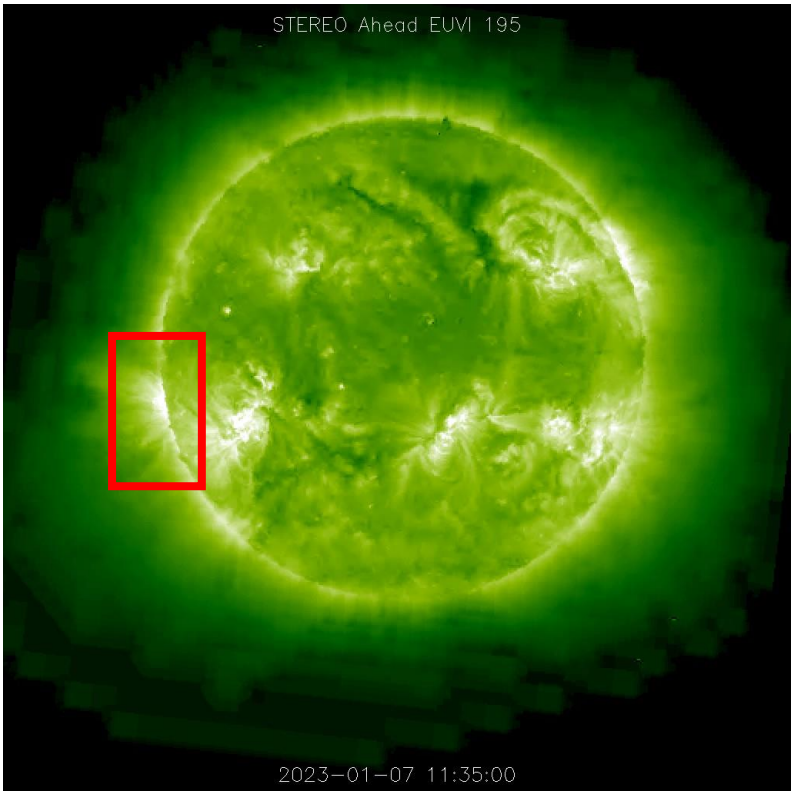
Figure 6 – STEREO Ahead - EUVI shows some bright flux (red box) just around the east limb – trailing behind AR3182.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases slightly through the period, due mainly to the risk presented by AR3182 as it rotates further across the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at background to moderate levels. No significant change is expected at first. Later in the forecast period predominantly moderate levels of the high energy electron flux are expected, due to continued coronal hole influence, initially from either CH60 or CH61, then during day 4 (10th) from CH62. The corresponding electron fluence values are forecast to remain below the Active (1e8 integrated pfu) levels, despite an

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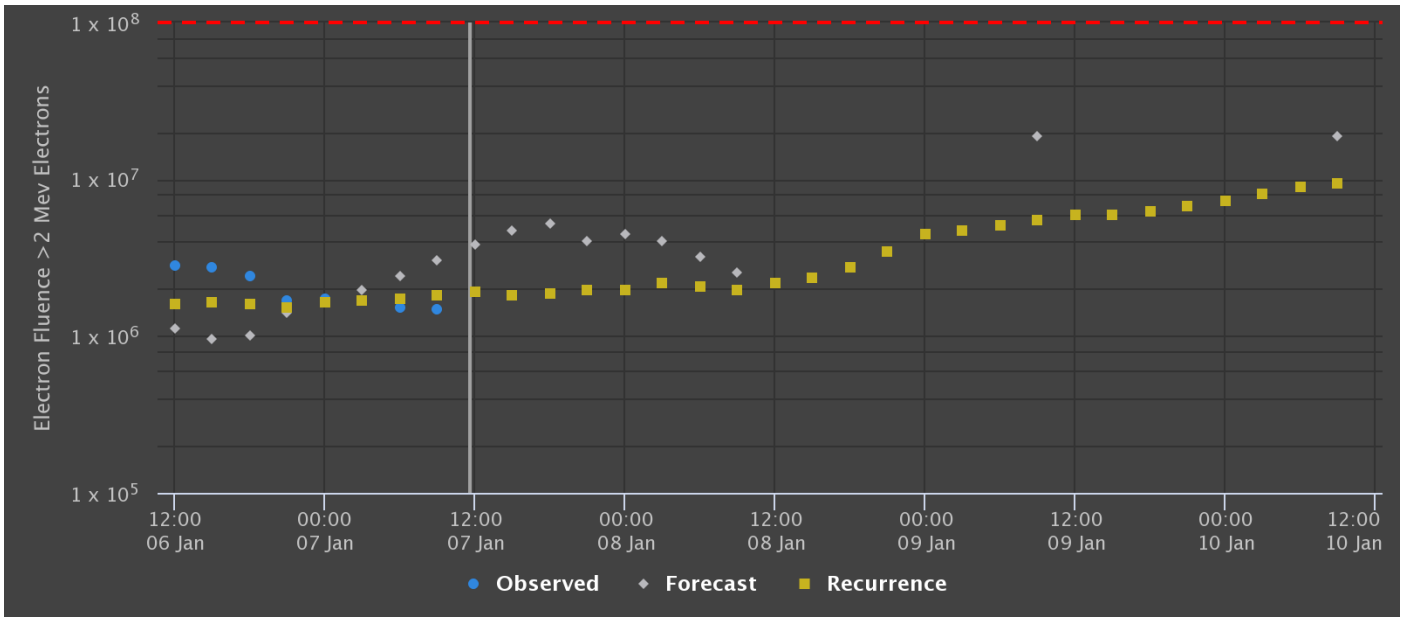
increasing trend. The Met Office REFM model is therefore considered to be offering reasonably good guidance.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	10	20	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 7: Met Office REFM.



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